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The Impact on Fatal Involvement of Commercial Vehicle Operation ITS User Services

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Abstract

Various Intelligent Transportation Systems (ITS) user services for Commercial Vehicle Operations (CVO) have the potential of reducing fatal involvements of commercial vehicles. Commercial vehicle operators subscribing to these user services, because of automated monitoring, will tend to operate in a safer fashion. The resources saved through the automated inspection process may then be devoted to the manual inspection of those commercial vehicle operators that are deemed to be less safe. Statistical analyses are conducted to determine the quantitative relationships between fatal involvements and the out-of-service violations to the numbers of inspections. The impact of ITS CVO user services on fatal involvements is then estimated.

KEYWORDS: Commercial Vehicle Operations (CVO), Intelligent Transportation System (ITS) fatal involvements

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Section 1

Introduction

The Intelligent Transportation Systems (ITS) program is concerned with the application of advanced technologies to address safety, mobility, productivity, and environmental issues for surface transportation in the United States. These technologies include the integrated use of information processing, communications, and control to provide various user services that are defined in terms of benefits for potential users.

A number of user services have been identified for commercial vehicle operations (CVO). CVO user services such as commercial fleet management and commercial vehicle administrative processes impact CVO productivity and mobility. Other CVO user services, affect commercial vehicle safety. These include electronic clearance, on-board safety monitoring, automated safety inspection, and hazardous materials incident notification. These latter user services augment and, in some cases, replace existing manual commercial vehicle inspection processes. Vehicles equipped with these services that pass the automated credentialing and safety validation process may forego a manual inspection.

Commercial vehicle electronic clearance enables a vehicle equipped with a transponder to have its weight, safety status, and credentials checked at mainline speeds as it approaches an inspection facility. A vehicle conforming with legal and safety regulations may then pass the inspection facility without delay.

On-board safety monitoring systems determine the safety status of the vehicle, cargo, and driver. Vehicle monitoring senses and collects data on the condition of various vehicle components that could affect safety such as the brakes, tires, and lights. Cargo monitoring senses unsafe vehicle cargo conditions such as cargo shifts. The driver monitoring function collects data on driving time and driver alertness. If unsafe conditions are detected, warnings can be provided to the driver and, subsequently, transmitted to the carrier and the appropriate enforcement authorities.

Automated roadside safety inspections allow electronic access to the safety records of carriers, vehicles, and drivers in order to determine which vehicles should be stopped for an inspection. The inspection process is automated through the use of sensors and diagnostics to establish the integrity of safety related vehicular components.

Finally, ***hazardous material incident notification*** provides enforcement and response teams with information on cargo contents. When an incident involving hazardous materials occurs, the system helps to identify the nature of the hazardous materials as well as the location and type of incident.

The adoption of these safety-related CVO technologies is expected to be on a voluntary basis, at least during the initial market penetration. We would therefore expect that carriers already having a strong commitment for safe operation might self-select themselves as participants1 If a part of the commercial vehicle fleet is equipped with these technologies, then the authorities can focus their manual inspections on those vehicle operators that are mote likely to drive unsafe vehicles in unsafe ways.

The purpose of this study is to determine the impact of the CVO technologies discussed above on the involvement of commercial vehicles in fatal highway accidents (called fatal involvements). In addition, we examine the impact of inspections on vehicle out-of-service (OOS) violations. The determinants of commercial vehicle fatal involvements and OOS violations are presented in the next section. The empirical data used in this study are discussed in Section 3 and, in Section 4, we present the statistical analysis and results. Section 5 presents the conclusions.

1 Previous studies have sbown that motor carriers differ substantially with respect to their accident rates. Characteristics of motor carriers such as firm size, type of freight hauled, and safety management practices affect commercial motor vehicle accident rates [1,2].

Section 2
Determinants of Fatalities and OOS Violations

The number of fatal involvements of commercial vehicles can be viewed as a function of the level of commercial vehicle activity, the nature of this activity, and the level of commercial vehicle inspections. We also view the numbers of OOS violations as a function of the number and types of inspections. The variables representing these factors and the rationales for including them are discussed below. A multivariate analysis is conducted to determine the independent impact of commercial vehicle inspections on fatal involvements.

2.1 Vehicle Miles Traveled

The number of fatal involvements depends upon the number of commercial vehicle highway accidents. Highway accident numbers, in turn, are related to the level of commercial vehicle activity as measured by the vehicle miles traveled (VMT). Since accident data are not as well reported as fatal involvement data, we express the number of commercial vehicle fatal involvements directly in terms of the VMT. VMT is expected to have a positive sign in the empirical estimation of fatal involvements.

2.2 Rural VMT Fraction

Accidents occur on a variety of roadways and the roadway type may influence the probability of accidents and associated fatal involvements. Mean vehicle speed, which is a determinant of commercial vehicle fatal involvements, differs between urban and rural roadways. For example, in 1992, the average speed on urban interstates was 57.7 miles per hour, while for rural interstates (based on partial data), it was 61.3 miles per hour [3, p. 222] Similarly, for other roadway types, a speed differential exists. This speed differential is due in part to speed limits that may differ between like rural and urban roadways and also to the fact that congestion is greater in urban areas. While congestion may increase the number of accidents, these accidents will tend to be less severe leading to fewer fatal involvements because of the lower speeds involved. In addition, the time between an accident and the notification of emergency medical services, which has been shown to be a determinant of fatalities [4,5], is greater for rural areas [6]. We account for these factors by introducing as an explanatory variable the fraction of total commercial VMT that is rural, FRUR. Fatal involvements are expected to increase as FRUR increases.

2.3 Level of Commercial Vehicle Inspections

The Motor Carrier Act of 1980, while reducing both the cost and regulation of entry to the motor carrier industry, adversely affected roadway safety [7]. Increasing competition lowered the profitability of commercial vehicle operators. Consequently, safety-related spending by some carriers declined and drivers had incentives to violate both hours-of-service regulations and the roadway speed laws. To combat these trends, government expenditures on safety regulation through commercial vehicle inspections increased substantially. In 1984, the total number of commercial vehicle inspections was about 159 thousand, while by 1992 it increased to about 1.6 million [8, p. 281.

A study based on California data showed that the inspection rate (i.e., inspections per 100,000 miles of commercial vehicle traffic) influences the commercial vehicle accident rate [7]. The safety of commercial vehicles and their drivers is affected by both the threat of inspections as well as the actual inspection process. Inspections, however, may differ by quality and thoroughness. Five levels of inspection have been identified [8, Attachment III] and the relative prevalence of these levels may differ among the states. These levels are:

- Level I, North American Standard - includes extensive vehicle checks, brake performance measurements, driver qualification inspections, and hours-of-service inspections
- Level II, Walk around vehicle and driver inspection - vehicle inspection conducted without inspecting underneath of vehicle; inspections of driver qualifications and hours-of-service
- Level III, Driver only inspection - highway examination of driver related aspects of the North American Standard
- Level IV, Special inspection - a one time examination of a particular item
- Level V, Terminal inspection - inspection of a vehicle at a carrier's terminal

Note that Level I incorporates the inspection activities of Level II, while Level II incorporates those of Level III. Since Levels IV and V represent only about 1.7% of the total number of inspections, we will ignore these levels in the subsequent analysis. Accordingly, we define three different commercial vehicle inspection numbers, namely: INSPl, the number of Level I inspections; INSP2 the number of Level II inspections, INSP3, the number of Level III inspections. We expect commercial vehicle fatal involvements to vary negatively with these inspection numbers. Moreover, we expect the effect of INSPl to be stronger than that of INSP2 which in turn will be stronger than the effect of INSP3.

The number of vehicle OOS violations is also expected to be a function of the number and types of inspections. We expect that vehicle OOS violations will vary positively with the fraction of inspections conducted at Level I and the time devoted to these inspections.

Section 3

Empirical Data

Summary statistics for the variables in the commercial vehicle fatal involvement model are shown in Table 3-1. The data are for individual states in the United States during 1992.

The data for the number of fatal involvements of commercial vehicles was obtained from reference [9, p.11]. The mean number of fatal involvements across the states was 80.4 with a minimum of zero for the District of Columbia and a maximum of 373 for California.

Out-of-service violation data was obtained from reference [11, Attachment III-3]. The mean number of OOS violations was 9,362 with a minimum of 493 in the District of Columbia and a maximum of 45,395 in Tennessee.

Data for the commercial vehicle miles traveled was obtained from reference [10, p. V- 117]. The mean VMT is 3,554 million miles with a minimum of 102 million for the District of Columbia and 19,710 million for California.

The fraction of commercial VMT traveled on rural roadways was calculated from the percentages given in reference [10, pp. V-123 - V- 127]. The mean fraction was .6 with a minimum of 0 for the District of Columbia and a maximum of .9 for Montana.

The numbers of inspections at the various levels were obtained from reference [1], Attachment III-4]. Level I inspections were the dominant form with a mean of 20,296, a minimum of 1306 for Alaska and a maximum of 113,554 for Tennessee. Level II inspections had a mean of 9697 with a minimum of zero for Tennessee and Hawaii and a maximum of 50,999 for Texas. For Level III inspections, the mean was 3,107 with a minimum of zero for Tennessee, Hawaii, and Virginia and a maximum of 22,122 for Illinois

The mean percentage of Level I inspections was 58% with a low of 18% for Texas and a high of 96% for California Finally, the mean time for Level I inspections was 33 minutes with a low of 21 minutes for California and a high of 49 minutes for Pennsylvania.

Table 3-l. Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Number of Fatal Involvements	80.4	76.4	0	373
OOS Violations	9,362	8,740	493	45,395
Commercial Vehicle Miles Traveled (in millions)	3,554	3,508	102	19,170
Fraction of VMT that is Rural	.60	.21	0	.90
Number of Level I Inspections	20,296	21,277	1,306	113,554
Number of Level II Inspections	9,697	11,483	0	50,999
Number of Level III Inspections	3,107	4,577	0	22,122
Fraction of Level I Inspections	.58	.21	.18	.96
Mean Time for Level I Inspection	33	8.3	21	49

Section 4

Statistical Analysis and Results

In the next subsection, we discuss the statistical model and its estimation for the number of fatal involvements. In subsection 4.2, the model for vehicle OOS violations is presented and estimated. Subsection 4.3 discusses commercial carrier characteristics and their relationship to accidents. In subsection 4.4, we discuss the optimization of existing manual inspections, given fixed resource constraints. Finally, we present a parametric analysis of the impact of CVO ITS technology on fatal reduction involvement in subsection 4.5.

4.1 Fatal Involvements

The number of fatal involvements, NF, is the dependent variable in the statistical analysis. Our interest centers on the effect of the explanatory variables discussed above on the number of fatal involvements. Since the number of fatal involvements assumes non-negative integer values across the state data, ordinary least squares regression analysis, requiring a continuous dependent variable, is inappropriate. Instead, we use a Poisson regression model which is useful when the dependent variable (i.e. the number of fatal involvements) represents a count of events. The number of fatal involvements then is a random variable with a Poisson distribution given by:

$$\mathrm{Prob}(NFi=r) = \exp(-\,Oi)\ \frac{(Oi)^{r}}{r} \qquad (1)$$

where Oi is a parameter representing the expected number of fatal involvements for state i. The expected number of fatal involvements is expressed as a function of the commercial **VMT** driven (VMT), the rural VMT fraction (FRUR), and the level of inspections as characterized by the numbers of Level I (INSP1) Level II (INSP2), and Level III (INSP3). The relationship is expressed in logarithmic form as:

$$\begin{aligned} \mathrm{In}(Oi) &= a\ 0 + a\ 1 *\mathrm{In}(VMT\ i\ ) + a\ 2 *\mathrm{In}(l{+}FRUR\ i\ ) + a\ 3 *\mathrm{In}(INSP1\ i\ ) \\ &\quad + a\ 4 *\mathrm{In}(INSP2\ i\ ) + a\ 5 *\mathrm{In}(INSP3\ i\ ) \qquad (2) \end{aligned}$$

where “In” is the natural logarithm and a 0 a 1 l , ... as are parameters that are to be empirically estimated The logarithmic form forces the expected number of fatal involvements, Oi, to be positive, permits the consideration of non-linear relationships between fatal involvements and the explanatory variables, and allows us to interpret the coefficients as elasticities. The relationship between the actual number of fatal involvements and the expected number of fatal involvements is given by:

1 Unity is added to the FRUR variable in the logarithm since FRUR can assume zero values. When an inspection variable is equal to zero, it is set equal to unity.

In(NFi) = In(Oi) + E i (3)

where Ei is the difference between the logarithms of the actual number of fatal involvements and the expected number.

The results of the empirical estimation of the parameter values are shown in Table 4-1.

Table 4-1. Analysis Results For Fatal Involvements

Variable	Parameter Estimate	Standard
Constant	-3.63	.31
VMT	1.09	.03
FRUR	.96	.18
INSP l	-.11	.03
INSP2	-.03	.01
INSP3	-.003	.009

The coefficient of determination, R^2, indicating the goodness of fit, is .96. Thus, 96% of the variation in fatal involvements is explained by the independent variables. All of the coefficients enter with the expected signs. The VMT and FRUR enter with positive signs, while the inspection levels INSPl through INSP3 enter with negative signs. The coefficients for VMT, FRUR, and INSPl are within the 1% level of significance. The coefficient of INSP2 is at the 5% level of significance, while INSP3 enters insignificantly.

Since the variables are expressed in logarithmic form, the coefficients of these variables in 4-2 are interpreted as elasticities. For example, the elasticity of fatal involvements with respect to changes in the inspection variable, INSP1 is -.11. Making a change in INSPl, indicated by
AINSPl, while holding the other variables constant, we can write the elasticity equation from (2) as

$$\frac{ANF}{NF} = -.11 * \frac{AINSP1}{INSP1} \qquad (4)$$

Thus, a 20% increase in INSPl would result in a 2.2% reduction in fatal involvements. The relative values of the inspection level variables indicate that, at the margin, Level I North

American Standard inspections are about 3.6 times more effective in reducing fatal involvements than Level II inspections that involve only walk-around and driver inspection. In turn Level II inspections are about ten times more effective at the margin than Level III inspections involving only driver inspection.

4.2 Vehicle Out-of-Service Violations

Since the number of OOS violations is also a count, we use a Poisson model for the same reasons cited in the previous subsection. The number of vehicle OOS violations, NOOS, is a random variable with a Poisson distribution given by:

$$\text{Prob}(\text{NOOS}_i = r) = \exp^{(-w_i)} \frac{(w_i)^r}{r!}$$

where w_i is a parameter representing the expected number of vehicle OOS violations for state i. The expected number of OOS violations is expressed as a function

$$\ln(w_i) = a_0 + a_1{*}\ln(\text{TINSP}_i) + a_2{*}\ln(\text{FLEVELI}_i) + a_3{*}\ln(\text{MTIMIE}_i)$$

where TINSP is the total number of inspections, PLEVELI is the fraction of those inspections that are Level I, and MTIME is the mean time for a Level I inspection.

The results of the empirical estimation of the parameter values are shown in Table 4-2.

The coefficient of determination, R^2, indicating the goodness of fit, is .88. Thus, 88% of the variation in the vehicle OOS violations is explained by the independent variables. All of the **coefficients enter with the expected positive signs and are significant within the 1% level of** significance.

Table 4-2. Analysis Results For Vehicle OOS Violations

Variable	Parameter Estimate	Standard Error
Constant	**-2.48**	**.03**
VMT	**-11**	**.003**
TINSP	**.96**	**.003**
PLEVELI	**.33**	**.003**
MTIME	**.28**	**.006**

The vehicle OOS violations track approximately linearly with respect to the total number of inspections. We see, however, from 4-3 that the number of OOS violations can be increased by increasing the fraction of Level I inspections or by increasing the mean time for these inspections. The results in Table 4-3 represent structural relationships that reflect existing technology for the conduct of inspections. For example, more time spent on brake inspections may yield a larger number of OOS violations. On the other hand, the introduction of ITS technology, such as automated brake inspection systems, may have an impact comparable to more time spent on manual brake inspections. In this case, automated brake inspections may be viewed as increasing the effective time spent on brake inspections even though the nominal time may have actually decreased. If the use of automated brake inspection technology can be interpreted as equivalently increasing the Level I mean inspection time by 30 minutes, then we would expect a 25% increase in the numbers of vehicle OOS violations.

Because of the high correlation between inspections and OOS violations, we were unable to enter OOS violations as an explanatory variable in the fatality equation. While an OOS violation may put a commercial vehicle out of service that would subsequently be involved in a fatal accident, it is the threat of inspection and the possibility of being declared OOS that is a major driving force in reducing the number of fatal involvements.

4.3 CVO Characteristics and Accidents

Previous studies have shown that accident rates vary widely with the characteristics of the commercial vehicle carrier [1,2]. Smaller carriers tend to have higher rates. Firms that operate more than 500,000 miles per year have an accident rate that is about half that for the smallest firms. Moreover, the accident rate of for-hire carriers is about 20% higher than that for private carriers. General freight carriers have an accident rate 45% higher than the corresponding rates of specialized carriers. Finally hazardous materials carriers exhibit accident rates about 22% higher than those of carriers not transporting these goods.

Clearly, given the magnitude of the gap that exists between the most safe and least safe carriers, substantial opportunities exist for the application of CVO ITS resources and standard inspections to narrow this gap. Indeed, as the number of inspections has grown in recent years, compliance and enforcement resources have been focused on those motor vehicle carriers that are thought to be of greatest safety risk. Within the Selective Compliance and Enforcement program, a Prioritization and Selection system was developed to objectively identify commercial motor carriers presenting the greatest potential highway safety risk and to prioritize these carriers for subsequent safety reviews or compliance reviews. State inspection programs have also focused their activities on the potentially unsafe carriers. For example, in 1992, carriers with l-l 1 power units experienced about 28% of inspections and had 33% of the violations, even though they made up about 15% of the commercial vehicle fleet nationally. On the other hand, carriers with 2000-5000 power units represented 3.3% of the inspections and 2.7% of the violations but made up about 6.6% of the fleet [12].

4.4 Optimization of Inspection Resources

Nevertheless, a need exists to further increase the consistency and efficiency of commercial motor vehicle enforcement procedures. Of the approximately 1.6 million inspections in 1992, 60% were at Level I, 29% at Level II, 9% at Level III, and 2% at Levels IV and V combined. Given that the mean time for Level I inspections was 33 minutes, that for Level II 28 minutes, and for Level III 22 minutes, we can ask what the optimal allocation of inspections based on time expenditures among the levels might be. There is a total resource allocation for inspections as measured by time, denoted TOTTIME given by:

$$TOTTIME = 33*INSP1 \; 28*INSP2 + 22*INSP3 \qquad (5)$$

The optimum allocation among inspection levels can be found by minimizing the number of fatal involvements, Φ, given by equation (2) relative to the total time allocation in (5). This optimization can be accomplished by the use of Lagrange multipliers. Defme an objective function, Z, such that:

$$Z = \Phi + h*(33*INSP1+28*INSP2 + 22*INSP3 - TOTTIME) \qquad (6)$$

Taking the derivatives of Z with respect to the Lagrange multiplier, *h*, and the variables INSP1, INSP2, and INSP3, setting the derivatives to zero and solving for the variables yields the optimal solution:

$$INSP1 = 3.1 * INSP2 \qquad (7)$$

and

$$INSP2 = 7.9 * INSP3 \qquad (8)$$

Thus, there should be about 3.1 times more Level I inspections than Level II and about 7.9 times more Level II inspections than Level III. Recognizing that the total number of inspections, INSP, is the sum of the various levels,

$$INSP = INSP1 + INSP2 + INSP3 \qquad (9)$$

and substituting (7) and (8) into (9) to solve for the individual inspection levels in terms of the total inspections, we get the optimum inspection ratio as shown in the last column of Table 4-3. For comparison purposes, the actual distribution among levels at the national level is shown in the second column. Level I inspections are underutilized from the perspective of an optimal allocation. This result agrees with the conclusions of an analysis in reference [11, p. 72] that the number of Level I inspections should be increased, based on the yield of out-of-service violations per inspection hour for the different types of inspections.

The results in Table 4-3 further show that the remaining levels are overutilized and some of the resources devoted to these types of inspections can be better allocated to Level I inspections.

Table 4-3. Actual vs. Optimal Inspection Level Distributions

	Actual Distribution	Optimal Distribution
Level I	60%	73%
Level II	29%	23%
Level III	9%	4%

Although the national averages shown in Table 4-3 for the actual distributions are relatively close to the optimal distributions, the distributions in many states differ widely from the optimal. For example, about 18% of inspections am Level I in both Texas and Illinois, while California, Kentucky, and New York each have over 90% Level I inspections. Therefore, individual states can better allocate their inspection resources to achieve an optimal fatal involvement reduction.

4.5 Impact of CVO User Services on Fatal Involvement Reduction

The implementation of the full complement of ITS CVO user services affecting commercial vehicle safety (i.e., electronic clearance, on-board safety monitoring, automated roadside safety inspections, and hazardous material incident notification) effectively provides the features of a Level I inspection and, in some cases, goes beyond the Level I features. For example, the driver monitoring function of the on-board safety monitoring system collects data on driver alertness, provides warnings to the driver and may transmit the information to the carrier or enforcement authorities. Manual inspection procedures only check the completeness of the driver's logbooks for hours-of-service and provide no means of determining the accuracy of the entries or how fatigued a driver actually is. Since fatigue has been estimated to be a contributing factor in forty percent of commercial vehicle accidents [13], the driver monitoring function may have an additional impact on safety.

However, the quantitative impact of CVO user services on fatal involvements is not immediately apparent. At least initially, the utilization of these services is expected to be on a voluntary basis. Thus, we may anticipate a selectivity bias to be at work, in that carriers that already follow safe procedures and have low accident rates will be the first to adopt the CVO services. These carriers will derive economic benefits from these services such as travel time savings leading to more efficient movement of goods, the avoidance of accidents occurring at inspection stations, and paperwork reduction [14].

On the other hand, carriers that operate unsafely initially may have economic incentives to avoid adopting the various CVO user services and, hence, they too may self select. These carriers may utilize unsafe vehicles since safety maintenance implies vehicle downtime and added costs. Moreover, the drivers for these carriers may have various incentives for violating hours-of-service regulations. If the economic advantages of unsafe operation outweigh the economic benefits of the CVO user services, then many carriers will initially choose to forego the use of these services.

Based on the considerations discussed above, the social benefits associated with the CVO user services derive from three factors. First, the carriers that already conduct their businesses in a safe manner will voluntarily implement the CVO services and will be much less of a resource drain on the existing manual inspection processes in the various states. As a result, the inspection authorities may better focus existing resources on that segment of the commercial vehicle fleet that is more likely to operate unsafely.

Secondly, as manual inspection resources become more focused, some carriers operating at the margin in an unsafe manner may find that the economic benefits of their marginally unsafe operation am exceeded by the economic benefits of CVO user service adoption. Therefore, they will eventually buy into the CVO program and become safer operators.

Lastly, carriers who view the economic benefits from unsafe operation to be greater than the economic benefits of CVO services adoption, may see their advantage decline. The economic incentive for safe commercial vehicle operation is a function of the probability of being caught and the penalties that result if caught [15]. From this perspective, the focus of manual inspection resources on unsafe carriers will increase the probability of being inspected, thus leading to more out-of-service violations and greater economic disincentives. Some of these firms will be encouraged to conduct themselves in a safer manner and may ultimately adopt various of the CVO user services.

The net effect of these three factors may be a reduction in the expected number of fatal involvements both from the adopters of the CVO user services and from those who choose not to adopt. The CVO user service adopters will initially come from the lower end of the fatal involvement rate distribution. By using these services, they may achieve further reductions in their fatal involvement rates. As the less safe operators adopt the CVO user services, they too will become more like the safe operators since the monitoring and control features of these services encourage safe operation.

While the exact impact of CVO user service adoption cannot be determined, we can parameter& its impact by the fatal involvement reduction ratio, f, which is a reduction factor applied to the mean fatal involvement rate, $\phi i/VMTi$, for state i. Given a market penetration, MP_i for state i, measured as a fraction of the VMT generated by carriers that have adopted CVO user services, their contribution to fatal involvements is:

$$CVOFAT = f * \phi i \quad (MP_i * VMT_i) = f * \phi i * MP_i \tag{10}$$

The remaining commercial vehicle miles, $(1-MP_i)VMT_i$, will be subject to manual inspections. If the total resources dedicated to manual inspections remains the same, then the likelihood of inspection for those carriers not adopting CVO user services will be greater. Further assuming that the resources are optimally allocated among the inspection levels as discussed in the previous subsection, the numbers of inspections as a function of the total time budget, TOTTIME, are given by:

$$INSP1=TOTTIME/42.9$$

$$INSP2=TOTTIME/133.2 \quad (11)$$

$$INSP3=TOTTIME/1048.5$$

Substituting these inspection numbers into equation (2) yields the fatal involvements for the remaining carriers given by:

$$\ln(NCVOFAT_i) = -3.76 + 1.11 *\ln((1-MP_i)VMTi) + .99*\ln(1+FRUR_i)$$
$$-.1*\ln(TOTtIME_i/42.9) -.03*\ln(TOTTIME_i/133.2)$$
$$-.007*\ln(TOTTIME-3/1048.5) \quad (12)$$

Then, the total number of fatal involvements for state i is:

$$FATi = CVOFAT, + NCVOFAT, \quad (13)$$

The results at the national level ARE presented in Table 4-4 for market penetrations of 10,20 and 30 percent and for fatal involvement rate fractions of .5, .33, and .25. There are 3521 fatal involvements for a 10% market penetration with a fatal involvement reduction ratio of .5. At the other extereme, there are 28 14 fatal involvements for a market penetration of 30% and a fatal involvement reduction ratio of .25. These figures can be compared to the actual number of fatal involvements of 3858. Thus, fatal involvements may be reduced from 8% to 27% depending upon the assumptions that are ma& regarding the fatal involvement reduction factor and market penetration.

Table 4-4. Fatal Involvements vs. Market Penetration and Fatal Involvement Reduction Ratio

		Market Penetrction		
		10%	**20%**	**30%**
Fatal Involvement Reduction Ratio	.5	3521	3308	3104
	.33	3457	3179	2911
	.25	3425	3115	2814

Section 5

Conclusion

The numbers of inspections at various levels were shown to have an impact on commercial vehicle fatal involvements and on vehicle OOS violations at the state level. A variety of CVO user services within the ITS program are oriented toward improving the safe operation of commercial vehicles. These user services, in effect, provide all of the features of Level I inspections through automated means. In addition, they provide features that go beyond the current capabilities of Level I inspections. We thus expect the CVO user services to contribute substantially to safe commercial vehicle operation with a consequent reduction of fatal involvements for those carriers that adopt the technologies. The widespread adoption of the CVO user services is also expected to impact the safety of carriers that choose not to implement these services since the current inspection resources can be focused on them.

For this study, we parameterized a plausible range of fatal involvement reduction ratios along with market penetrations to estimate the impacts of these two variables on fatal involvements. A more exact determination of the quantitative improvements in safety must await further empirical data from CVO operational tests and perhaps actual CVO user service implementations. The self-selection process by which commercial motor vehicle carriers voluntary adopt the CVO user services is an open question and has not been addressed in this study.

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